

[0097] Substrate defining elements such as channels and valves can be formed of any suitable material, such as silicon, quartz, glass, and polymeric materials. The substrate can be homogenous or formed of one or more elements bonded together, such as a silicon substrate having a bonded quartz cover. The cover and substrate are micromachined with system features, including the valves, passages, channels, heaters. Micromachining includes fabrication techniques, such as photolithography followed by chemical etching, laser ablation, direct imprinting, stereo lithography, and injection molding. For example, a preferred microfluidic system is fabricated by injection molding of a substrate comprising one or more cyclic olefins.

[0098] Referring to the inset of FIG. 1, a valve 714 includes upstream and downstream channels 1030, 1031 and a reservoir 1032. For clarity, TRS associated with valve 714 is not shown. Valve 714 includes a protrusion 1034 and an opposing surface 1033 associated with a passage 1035.

[0099] Referring to FIGS. 13a-13d, photolithographic masks suitable for using in micromachining a system of the invention are shown. Photolithography provides one approach for fabricating a microfluidic system. An example photolithographic process begins by deposit a metal, such as at least one of chrome and gold, onto a substrate. Techniques such as vapor deposition or electron beam sputtering can be used to deposit the metal layer. A preferred substrate for fabricating channel, passage, and valve elements is a 500 micron thick Dow Corning 7740 Pyrex wafer. The wafer is coated with a layer of photo-resist, such as by spin coating. A photolithographic mask 950 indicative of the elements to be microfabricated is used as a pattern. The substrate is exposed to a light source with the mask in place and the resist is developed. Patterning removes the resist from areas of the substrate that will be etched.

[0100] An etchant, such as an acid, is used to remove the metal layer protecting regions of the substrate where the resist had been removed. The resulting unprotected areas of the substrate are etched, preferably to a depth of about 50 microns, using an etchant, such as buffered hydrofluoric acid. Once etching is complete, the remaining resist and metal is removed. Holes are drilled to allow the introduction of thermally responsive material, as described above.

[0101] Heater elements are preferably fabricated upon a second substrate, such as a 500 micron thick quartz wafer. A metal, such as a 2500 angstrom thick layer of aluminum, is deposited onto the substrate, which is then coated with a layer of resist. The coated substrate is masked using a mask 952 and patterned as described above. Aluminum is removed, such as by etching, from the areas of the substrate where the resist has been removed. Subsequently, the remaining resist is stripped away.

[0102] A low temperature oxide layer is deposited onto the substrate. A layer of metal, such as a chrome-gold layer, is deposited over the oxide layer. The metal layer is coated with resist and patterned with a third mask 954, which preferably defines the pattern that will become the recess, which receives a flow through member. The chrome gold layer is etched to form the recess.

[0103] The low temperature oxide is etched to a depth of about 100 microns using an etchant such as an aqueous hydrofluoric/nitric acid mixture. The resist and chrome gold

layer is removed. Subsequently, the oxide layer is coated with a layer of resist and patterned with a fourth mask 956, which preferably defines the pattern for electrical contacts to the system. An etchant, such as buffered hydrofluoric acid is used to etch through the exposed oxide. Holes are drilled through the second substrate directly opposite to where the channel will be. The first and second substrate are bonded together, as understood in the art.

[0104] Stereolithographic approaches for fabricating systems of the invention increase the efficiency of prototyping and in manufacturing microfluidic devices. Hi-resolution (about 0.004" spot size) stereolithography allows channel designs to be rapidly formed into a working system. The time savings, cost savings, and flexibility of the stereolithography allows us to test more designs more quickly and cheaply than ever before.

[0105] The epoxy-based resins used by the conventional stereolithography devices are not well suited to some uses in microfluidic devices. They cannot withstand high temperatures, they absorb fluids (slowly), they are fluorescent under an excitation source, and they are not optically clear. These properties are not obstacles to basic fluidic tests, but for full tests of device functionality and for manufacture, a material with more robust properties and a method for forming it is needed. A material line from Ticona (a subsidiary of Celanese A. G.) called Topas, such as Topas 5013 can be used. The Topas material is formed by an injection molding process. The mold halves for this process are generated by stereolithography. This reduces the lead-time usually necessary to create molds. For short run parts, this method works well. In the long run, steel molds are preferably created. Injection molded parts represent a dramatic cost savings over parts that are created in glass and quartz by a photolithographic process.

[0106] While the above invention has been described with reference to certain preferred embodiments, it should be kept in mind that the scope of the present invention is not limited to these. Thus, one skilled in the art may find variations of these preferred embodiments which, nevertheless, fall within the spirit of the present invention, whose scope is defined by the claims set forth below.

What is claimed is:

1. A valve for use in a microfluidic system, comprising:
 - a substrate defining an upstream channel and a downstream channel joined by a passage, the passage comprising a first surface; and
 - a thermally responsive substance (TRS) disposed, when the valve is in the closed state, to substantially obstruct the passage, wherein pressure present in the upstream channel urges at least a portion of the TRS against the first surface.
2. The valve of claim 1, wherein the passage defines a central axis and the first surface is disposed at an angle to the central axis.
3. The valve of claim 1, further comprising a heat source in thermal contact with the TRS, wherein, upon actuation of the heat source, an opening motion of the TRS opens the passage.
4. The valve of claim 1, wherein upon opening the passage, at least a portion of TRS melts and enters the downstream channel.